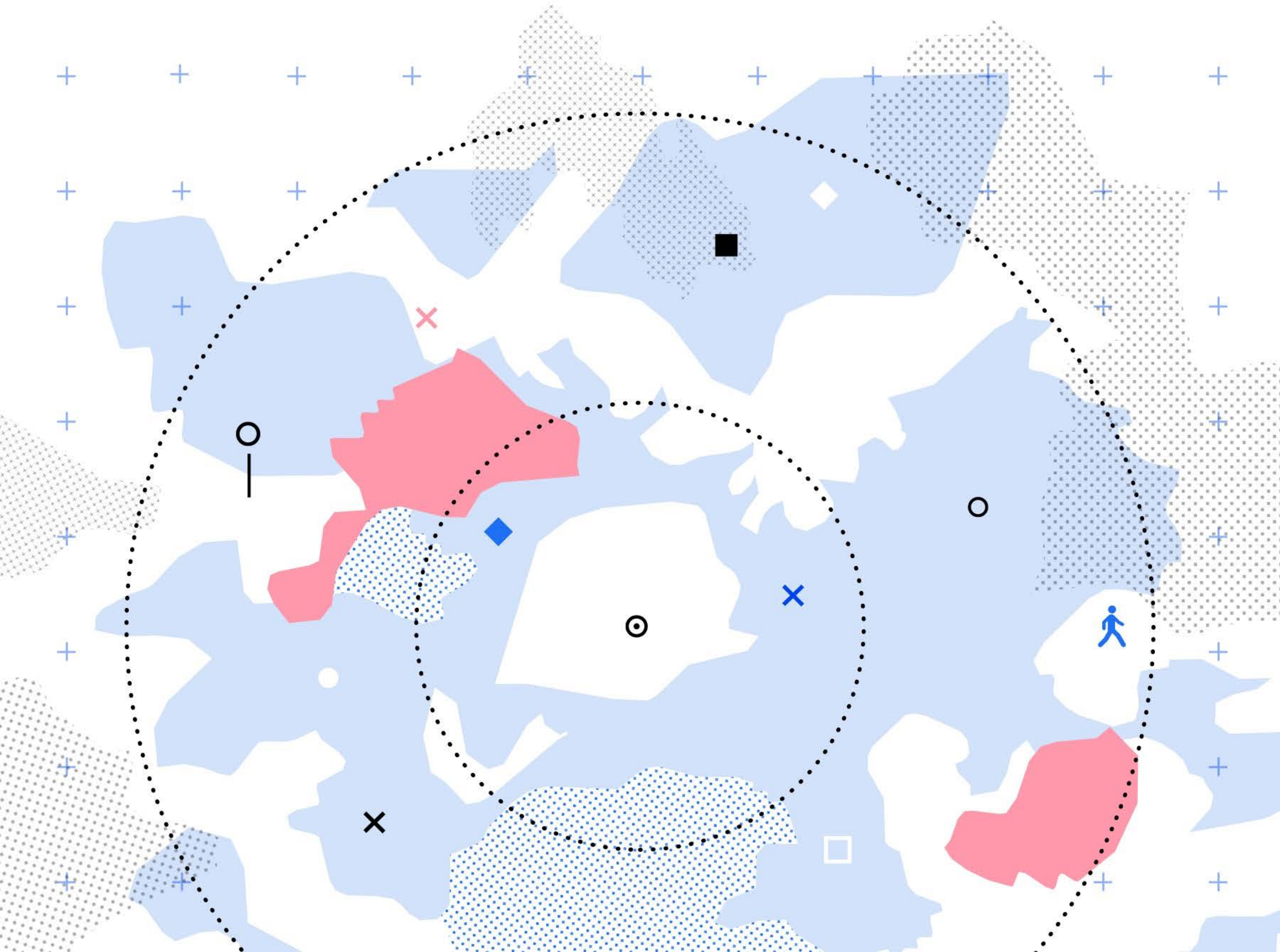
MORPHOCODE

Data on a human scale

A playbook on using location data and modern web technologies to explore the city



Discover the unexpected

When John W. Tukey wrote Exploratory Data Analysis in 1977, he embraced "the discovery of the unexpected" and stated that finding structures in data requires two things: tools and understanding. While we've come a long way since Tukey's seminal work and the availability of open data has increased substantially, making sense of that data remains time-consuming and requires domain knowledge.

With Morphocode Explorer, you can spend less time collecting, cleaning, and refining data and focus on your research. The powerful, easy to use interface allows you to explore location insights faster than ever.

In this report, you will learn more about the making of Morphocode Explorer and the research behind the tool.

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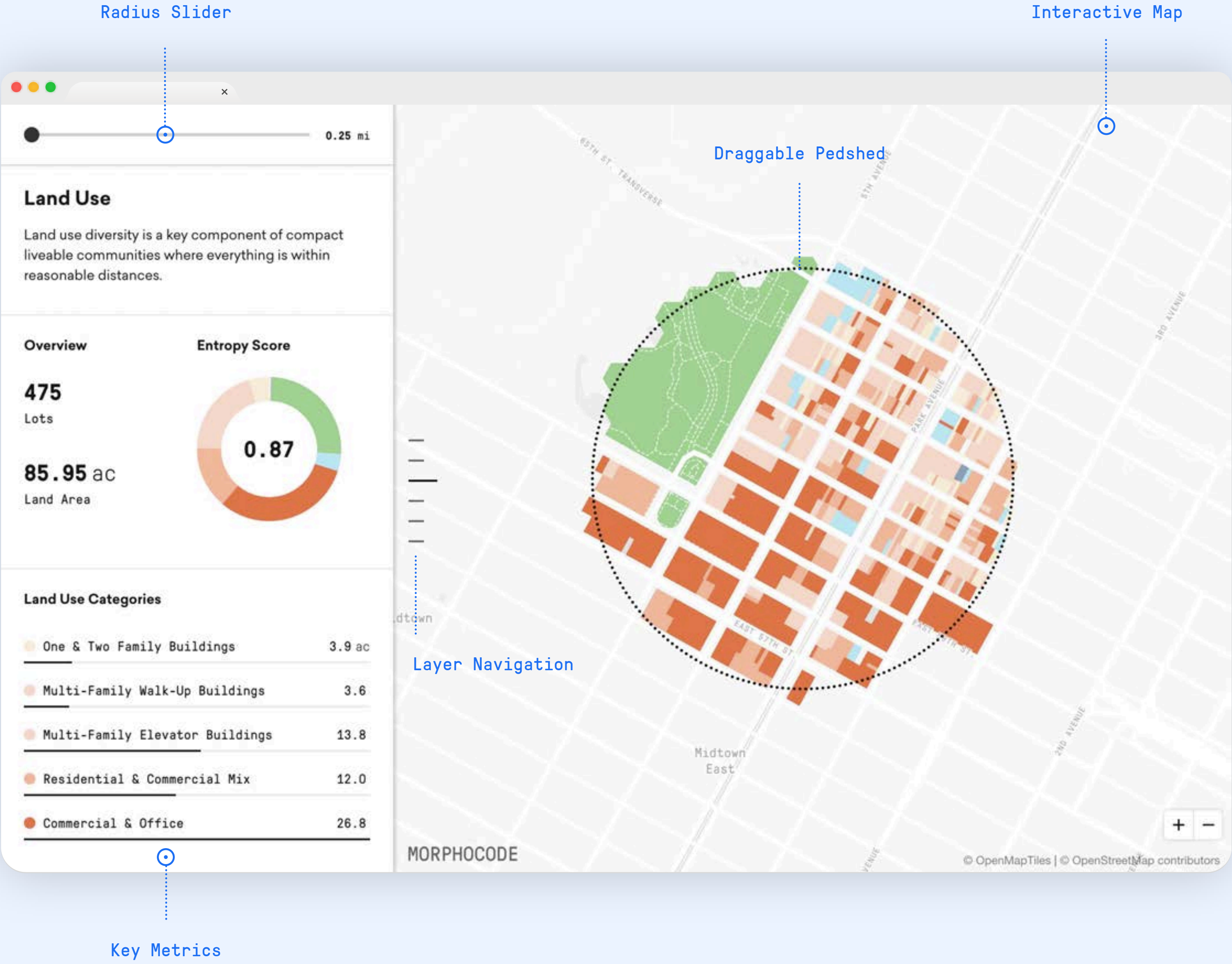
Contents

Morphocode Explorer is an urban analysis tool that allows you to assess existing site conditions, measure key urban indicators, and perform spatial research — directly in the browser.



PART 1

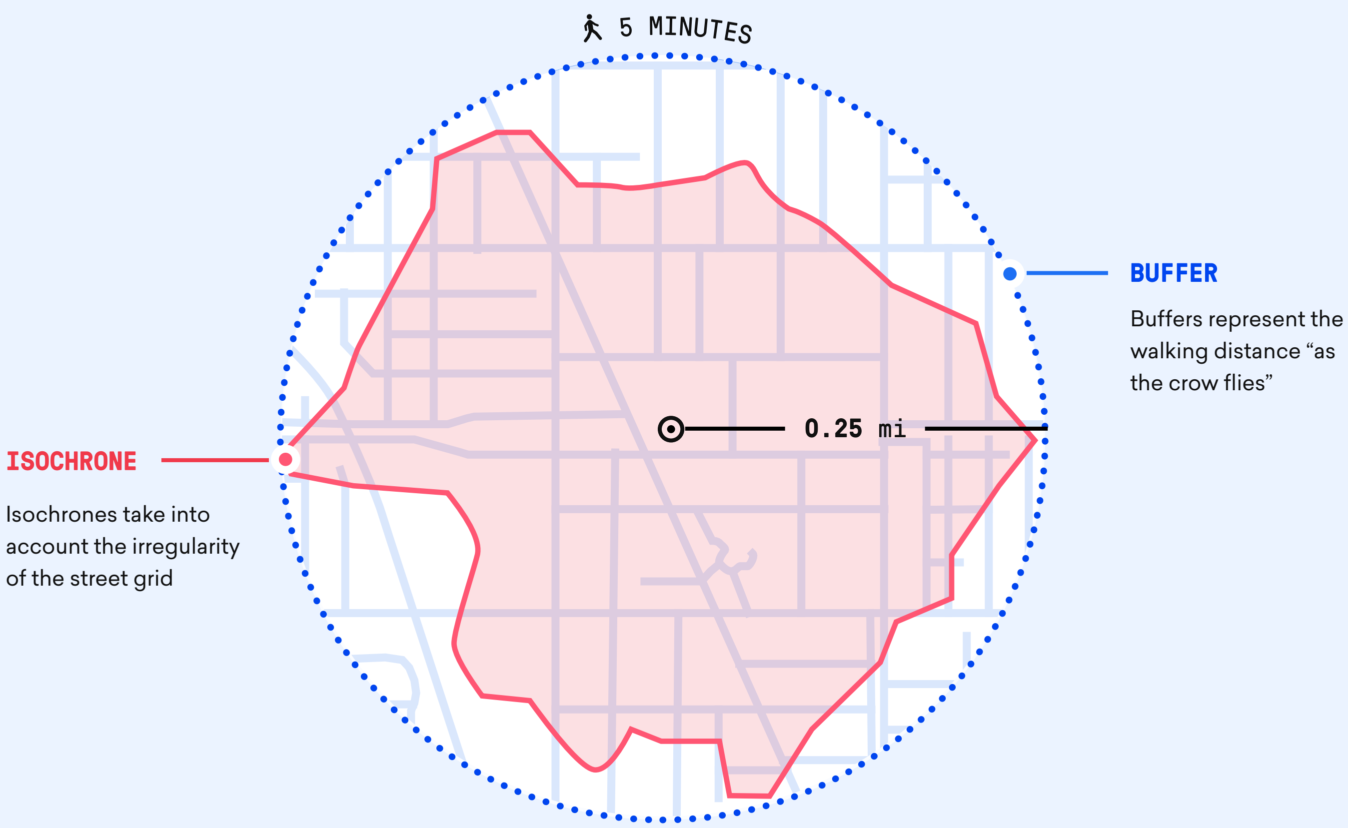
The 5-minute Walk

In urban analysis, the five-minute walk sets a scope for collecting both quantitative and qualitative data on a human scale.

The 5-minute walk, also known as the "pedestrian shed" is considered to be the distance people are willing to walk before opting to drive. Based on the average walking speed, a five-minute walk is represented by a radius measuring ¼ of a mile or about 400 meters. This rule of thumb is used to calculate public transport catchment areas or to determine access to destinations within neighborhoods.

Pedestrian accessibility can be visualized with isochrones or by using a simple buffer. Isochrone maps are often used in transportation planning to depict areas of equal travel time, while circular buffers represent distance "as the crow flies." They do not take into account the street grid or physical barriers that may affect how people move. However, using a circular buffer is a common way to identify areas that are accessible from a given location and to perform site analysis.

The pedestrian shed is usually placed around a community center or a common destination, such as a school or a public plaza, where social and commercial activity is focused.



“In a sense every great city is a conglomeration of small communities.”

- Clarence Perry

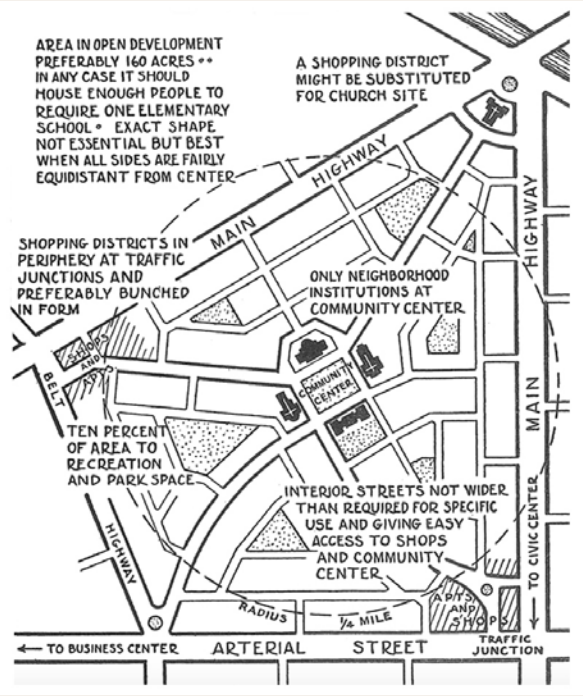
The 5-minute walk can be traced back to a concept known as the “neighborhood unit.” The neighborhood unit is a community model conceived in the 1920s by Clarence Perry. It gained popularity after being published in the 1929 Regional Survey of New York City.

Perry’s diagram provided a planning tool for a self-contained residential community. The study was largely influenced by the growing automobile industry in the United States and identified the car as “a new factor in the making of residential neighborhoods.” The goal of Perry’s research was to investigate the scale, spatial arrangement, and land use of residential communities and, ultimately, to provide a new planning framework.

Perry placed the elementary school in the center of the neighborhood and used it to determine the size and structure of the residential community: the school had to be within reach for all residents. This condition set the quarter of a mile walking distance at the core of the unit scheme. Together with local retail shops, public spaces, and residential buildings, the elementary school represented one of the four main functions in the neighborhood unit, as conceived by Clarence Perry.

Through the years, the neighborhood unit concept has received both high praise and severe critique. While Andres Duany has described Perry’s scheme as “the most famous diagram in the history of American planning,” other scholars have argued that the concept encouraged the development of gated communities. Nevertheless, Perry’s diagram has contributed to the idea of the pedestrian shed as a universal tool for measuring key urban indicators and planning compact, liveable neighborhoods.

Perry’s original neighborhood unit diagram (1929)

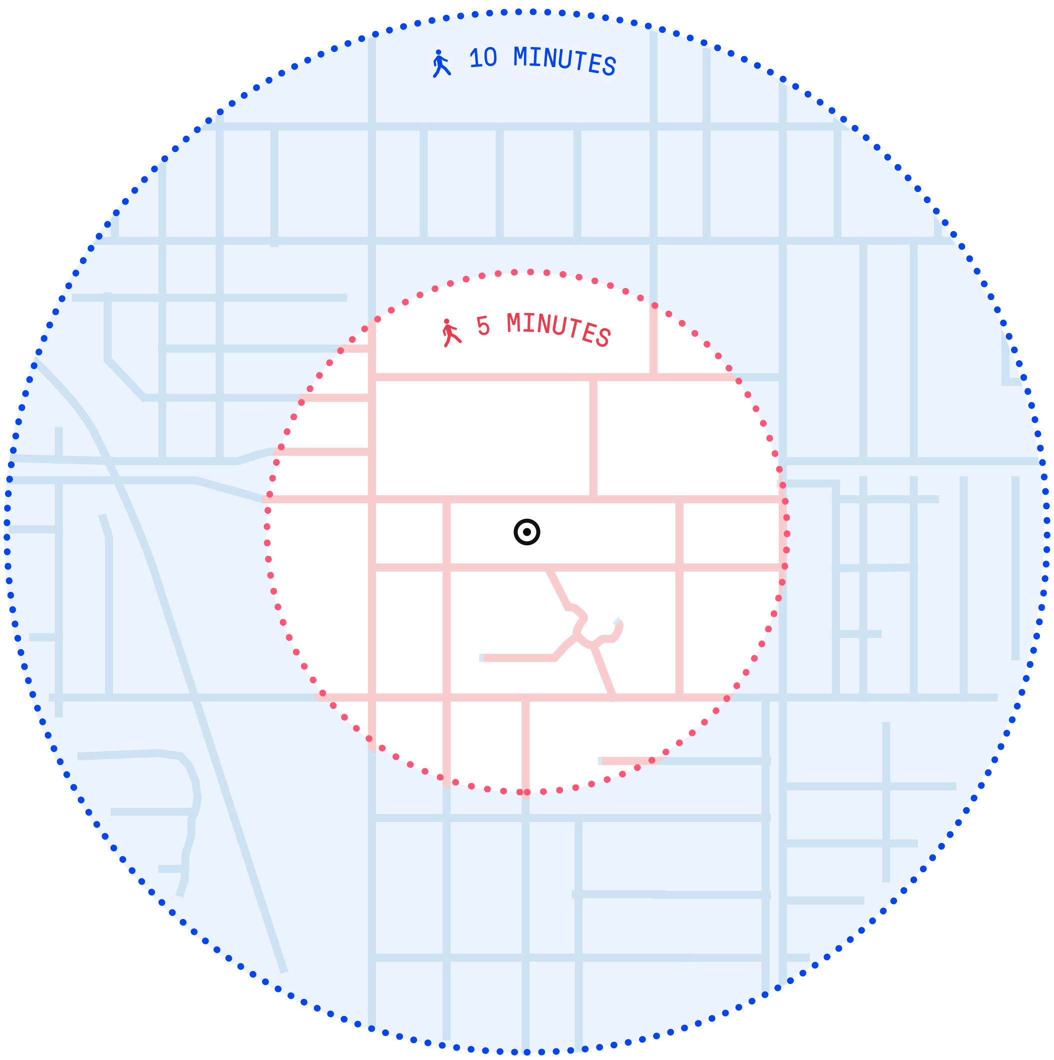


5 min vs 10 min
How long is too long?

Most researchers agree that the quarter of a mile (400m) walkable catchment is a reasonable distance for determining access to public services, and as a result, for measuring how walkable a community is.

In reality, the street grid, sidewalk design, environmental factors, and safety considerations affect how long people are willing to walk to reach a destination.

A large part of the research on walking behavior focuses on commuting and access to transit. Results suggest that most people are willing to walk longer to access rail than to access bus. That is why half-mile buffers are typically used to define catchment areas around rail stations, while quarter-mile buffers are applied around bus stops.

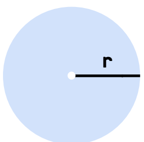


Walkable distances in policy

The pedestrian shed is used to determine the location of schools, measure accessibility to public open space, or even define the sidewalk width.

In site analysis, the pedestrian shed sets a scope for collecting spatial data and helps generate evaluation metrics around major community destinations. It also incorporates the human scale in urban policy and provides a pedestrian-oriented approach to city planning.

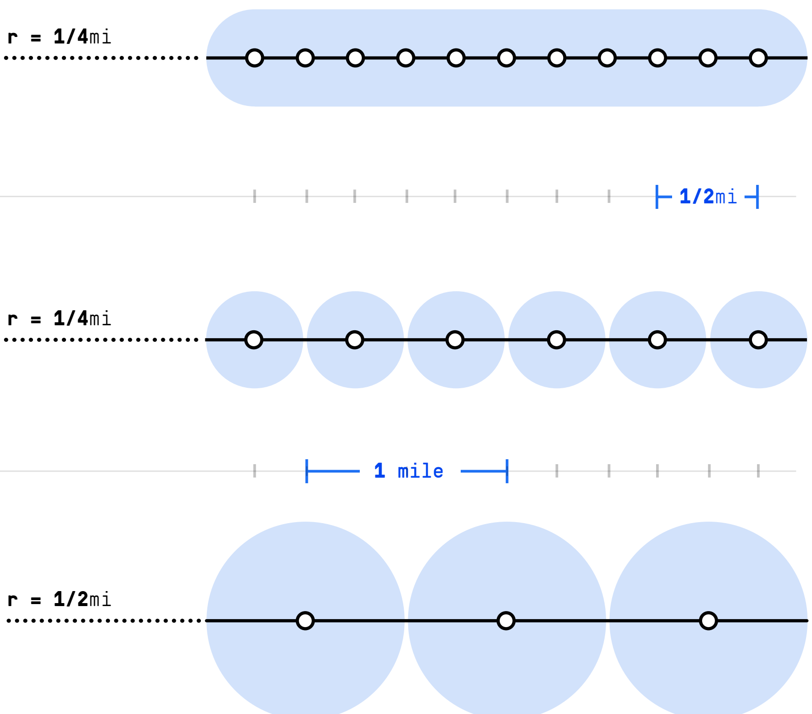
For example, one of the central goals of OneNYC – New York City's strategic development plan – is to increase the percent of New Yorkers who live within a 10-minute walk to public open space. The NYC Plaza Program, which celebrated its 10th Anniversary in 2019, is part of that effort. Since its inauguration, the program successfully combined the principles of tactical urbanism with a data-driven approach to planning and design.



Bus stops
A bus can stop every 1/8 mile

Tram stops
A tram can stop every 1/2 mile

Light rail
Light rail can stop every mile



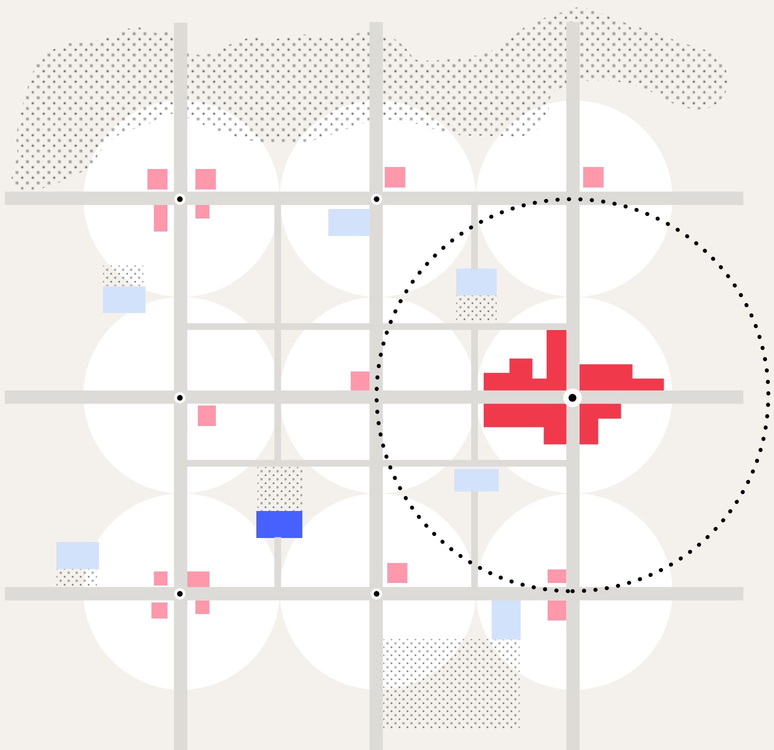
Meanwhile, cities like Portland, Detroit, Atlanta, and Melbourne have embraced the “20 Minute Neighborhood” concept.

According to Melbourne’s planning strategy, 20-minute neighborhoods aim to encourage local living by creating accessible, safe, and attractive local areas where people can reach most of their everyday needs within a 20-minute walk, cycle, or local public transport trip.

Walking distance metrics have also made their way into the world of LEED, namely The LEED for Neighborhood Development. This certification incorporates various indicators based on walking distances with an intent to reduce vehicle usage and encourage walking, biking, and transit use. The rating system relies on both quarter and half-a-mile buffers to measure components such as connectivity, neighborhood assets, and land use mix.

Liveable neighborhood hierarchy diagram

- District center
- Local centers
- Open space
- Primary school
- Secondary school
- Pedshed - 0.25mi
- Pedshed - 0.5mi
- Street grid



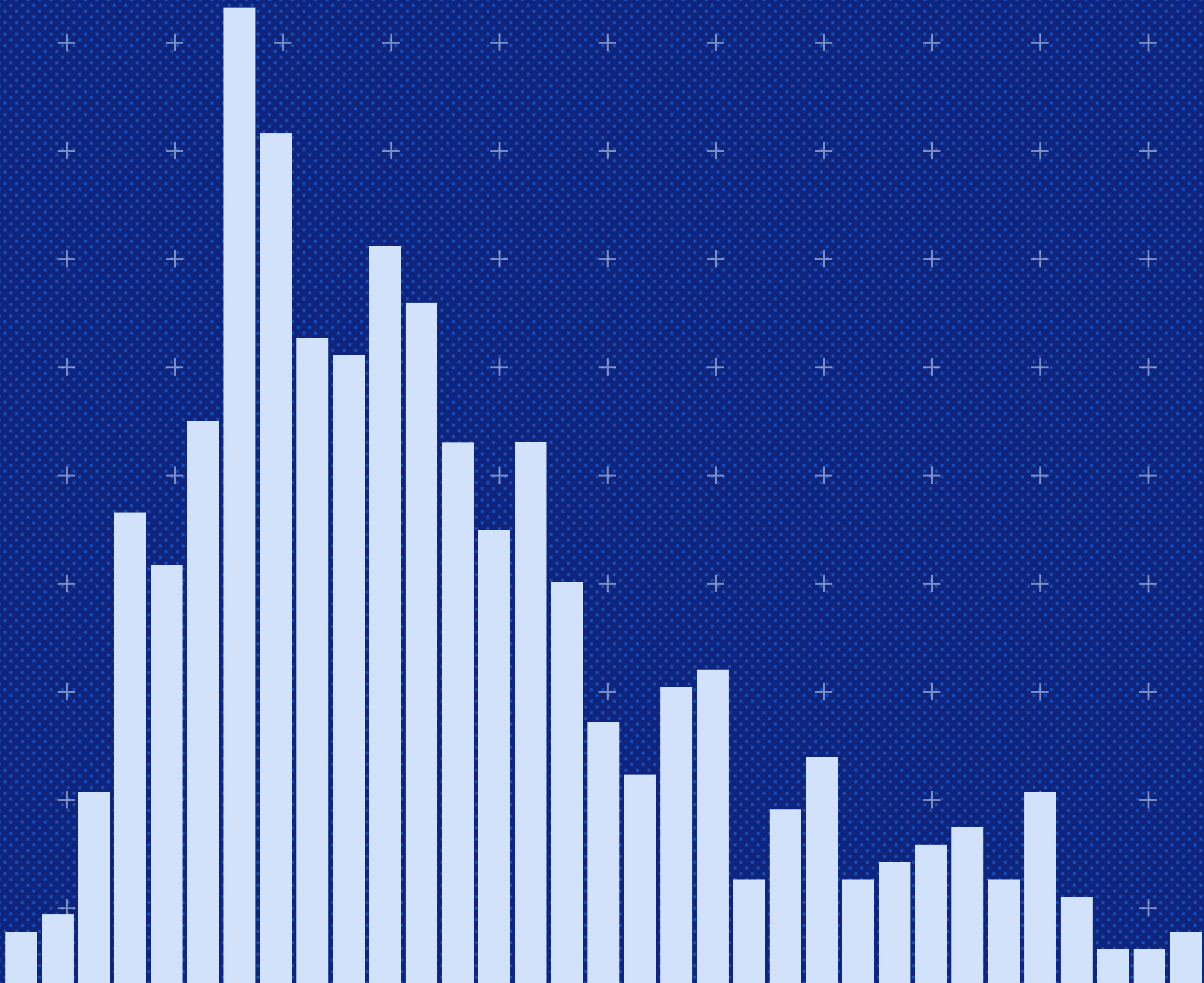
The pedestrian shed is a universal tool for urban analysis. It is used to evaluate key urban metrics around major community destinations.

Walking is a form of active transportation: we walk to reach destinations, for leisure, or to access transit services en route to more distant destinations. The 5-10 min walk is the most common scale for walking activities in an urban environment. Especially when it comes to reaching transit or running daily and weekly errands. We tend to choose the shortest, safest, and most pleasant routes for these recurring journeys.

Whether we choose to walk and for how long depends on many location-specific factors like safety, street design, and scale of the urban environment. It is also a matter of personal choice. The pedestrian shed of 5 - 10 minutes walking distance is deeply embedded in transit service planning. It is also the building block of liveable neighborhoods and an essential tool for measuring walkability.

PART 2

Measure what matters



Urban performance measures

Peter Drucker laid the foundations of modern management, insisting that you can't improve what you can't measure.

In urban planning, this line of thought has transformed the way we set goals, track progress, and analyze the effects of implemented projects and policies. Urban performance measures help communities make informed decisions and measure results against goals.

Land use mix

Street Network

Built Density

Points of Interest

Transit Network

Housing Density

Cycling / Micro Mobility

Figure Ground

Demographics

Safety

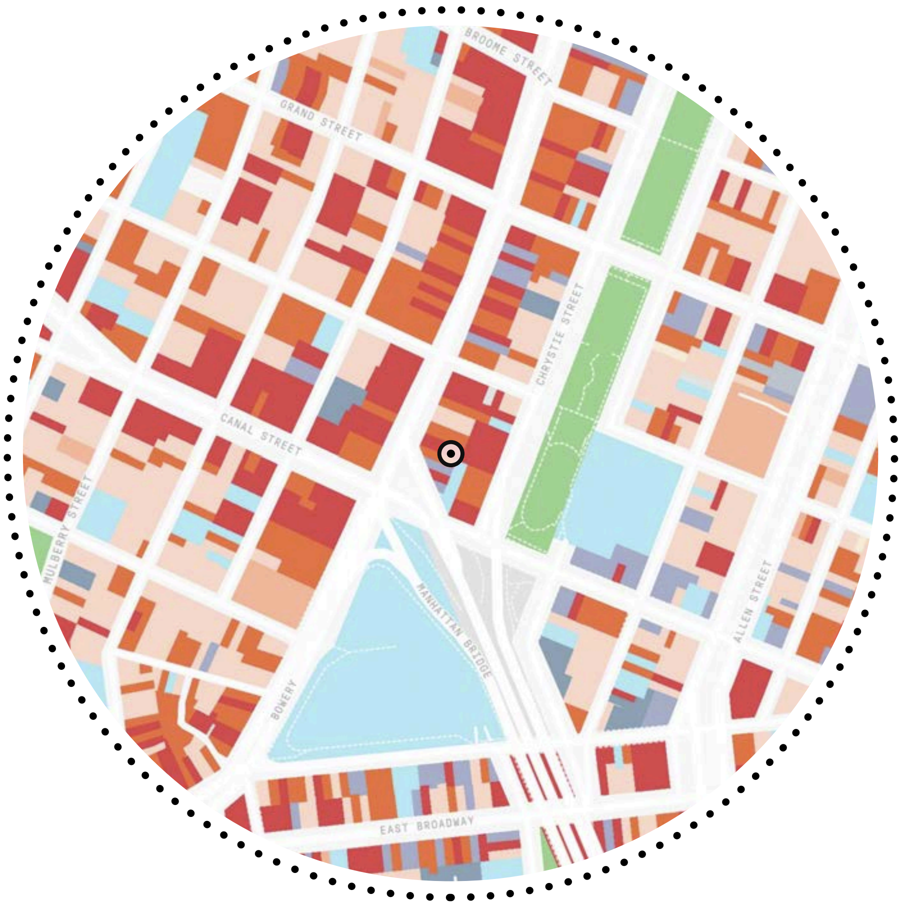
Land Use Mix

Land use data reveals the general distribution of existing functions and the proximity to destinations or community-serving facilities within the area. Compact, well-connected neighborhoods provide a good mixture of uses by including housing, retail, office, and community facilities within walkable distances of each other.

Land use mix affects travel mode choice and is an essential component of walkability. Mapping land-use helps you to determine access to public spaces and institutions like parks and schools or to identify vacant land for future development.

Key urban indicators

- Ranking of land use by area
- Entropy score
- Access to open space
- Vacant land



Built Density

Floor area ratio (FAR) is a standard urban indicator that measures urban density. It is calculated by dividing the total floor area of the constructions on the lot by the lot area:

```
FAR = FLOOR AREA / LOT AREA
```

Higher FAR typically corresponds to dense areas in the city center, while lower FAR is associated with less dense areas.

Zoning regulations usually **set a maximum allowed FAR** for each lot.

Built density a.k.a. Intensity of development is closely related to FAR. It is calculated as a percentage by dividing the **FAR of the lot** by the **maximum allowed FAR**:

```
DENSITY = BUILT FAR / MAX ALLOWED FAR * 100
```

Key urban indicators

- Overbuilt land area
- Underbuilt land area
- Median built density
- Distribution of lots by density

Transit Network

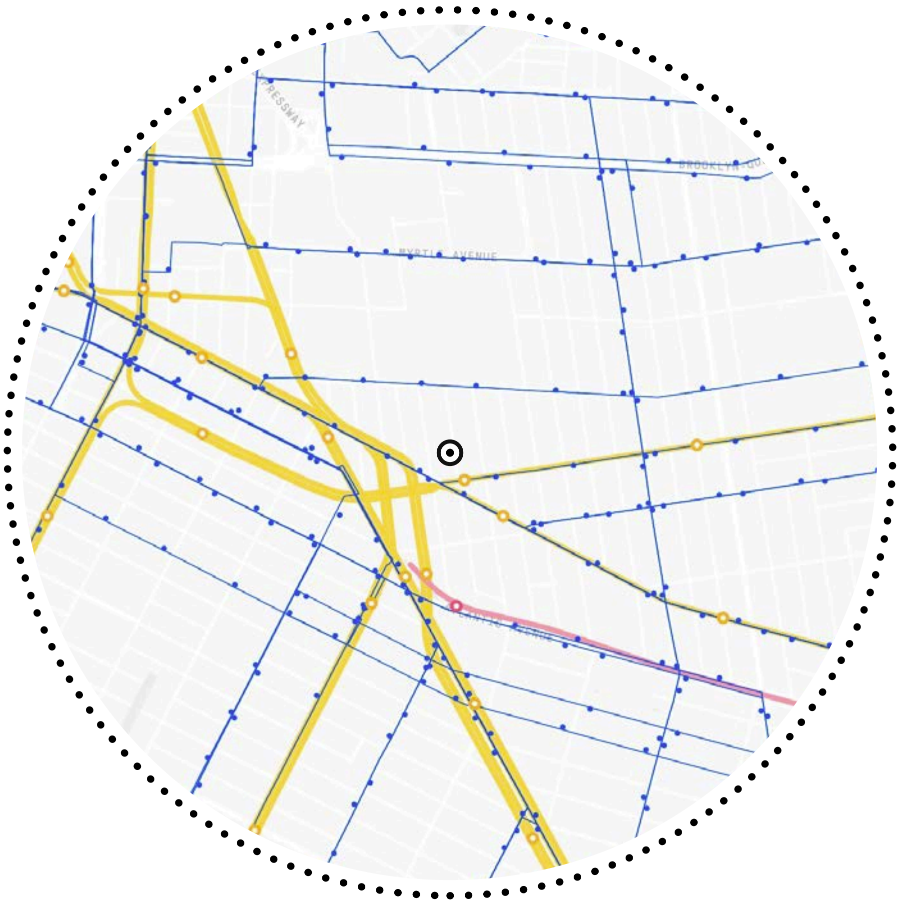
Distance is the primary factor affecting travel mode choice. Access to transit within walking distances of places where people live and work is crucial for maintaining the economic vitality and quality of life in cities.

Research on walking behavior suggests that most people are willing to walk about ten minutes to reach a rapid transit station and about five minutes to a local bus stop. That is why a quarter-mile buffer is used to determine catchment areas around bus stops, while a half-mile buffer is usually applied around rail stations.

Higher stop density encourages residents to walk to transit. It provides better accessibility and shorter trips to nearby stations.

Key urban indicators

- Access to subway stations
- Access to bus stops
- Access to rail stations
- Transit line diversity



Demographics

Multiple factors determine a neighborhood's context. Among them, the demographic and socioeconomic characteristics are essential metrics for understanding existing conditions.

Census data provides valuable insights into the demographic character of neighborhoods and is the primary source of information on topics like racial diversity, age, and sex distribution for every community. It allows us to isolate trends, observe how the population declines over time, or to recognize social displacement processes.

Key urban indicators

- Total population
- Population density
- Racial / ethnicity groups
- Age / Sex distribution
- Percent Female
- Racial Diversity Index

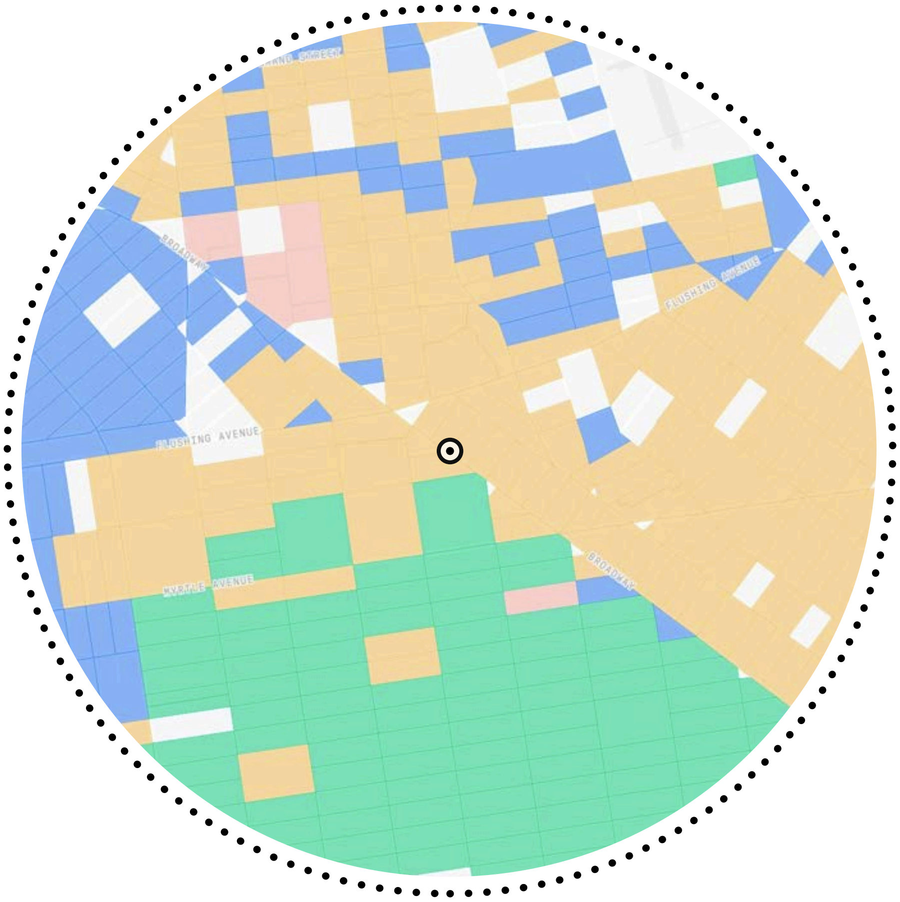


Figure Ground

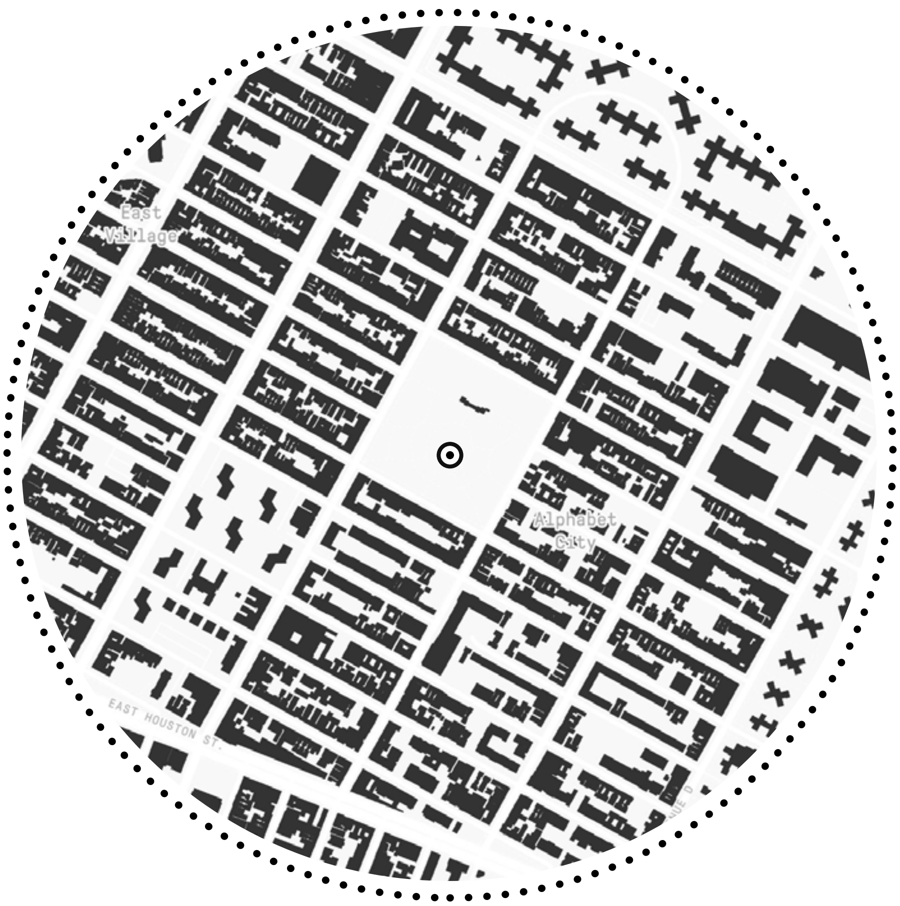
A figure-ground diagram is a mapping technique used to illustrate the relationship between built and unbuilt space in cities. Land coverage of buildings is visualized as solid mass (*figure*), while public spaces formed by streets, parks, and plazas are represented as voids (*ground*).

In urban planning, this simple yet powerful graphic tool is used to explore built form patterns and the continuity of open space.

The figure-ground diagram is an important element of urban analysis. It is a great way to study the grain of development and the overall morphology of the city.

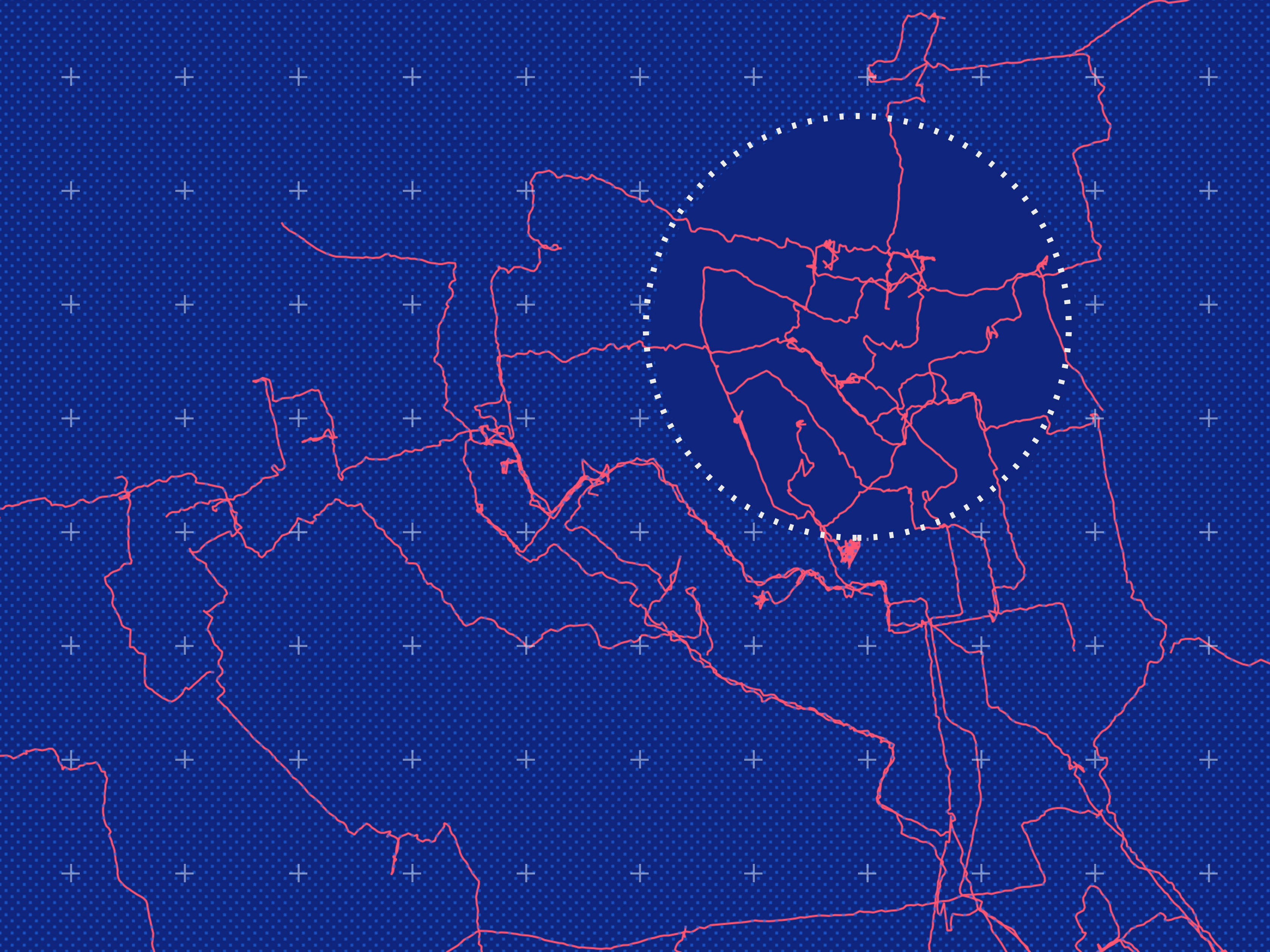
Key urban indicators

- Number of buldings
- Footprints area
- Solid / Void ratio



PART 3

Morphocode Explorer



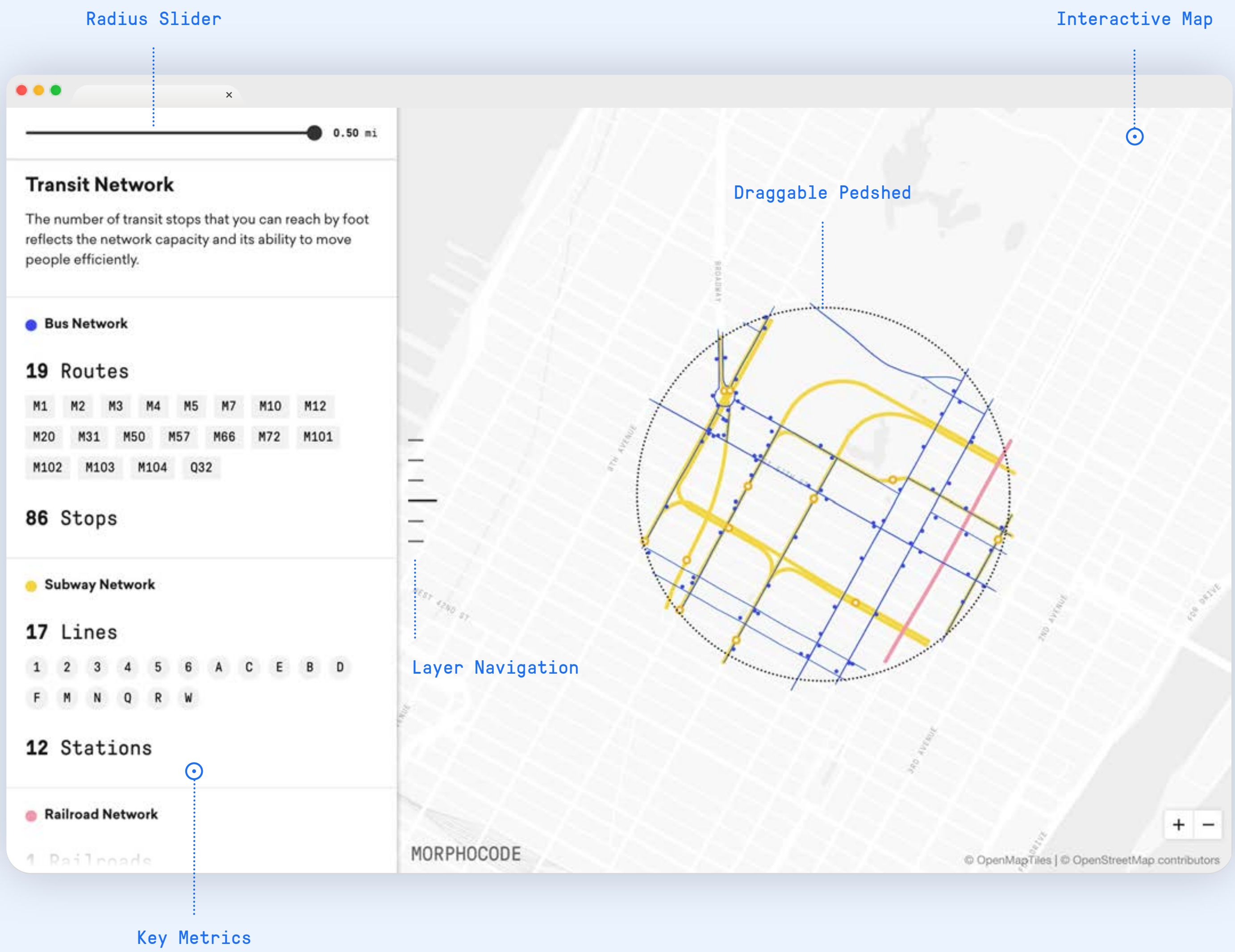
Designed for discoveries

As Dieter Rams famously said, *"Good design is as little design as possible."* So it is essential to identify the primary user interactions early on and put them at the core of the tool.

In Morphocode Explorer, you can drag the circular pedshed to select a location on the map, while the sticky slider lets you quickly adjust the radius of the study area.

The interface combines a map and a sidebar containing various urban indicators. The metrics are organized into separate layers: *land use, built density, transit network, demographics,* and *figure-ground*.

You can scroll through the sidebar to switch between the layers and explore the various charts and data visualizations.



From idea to implementation

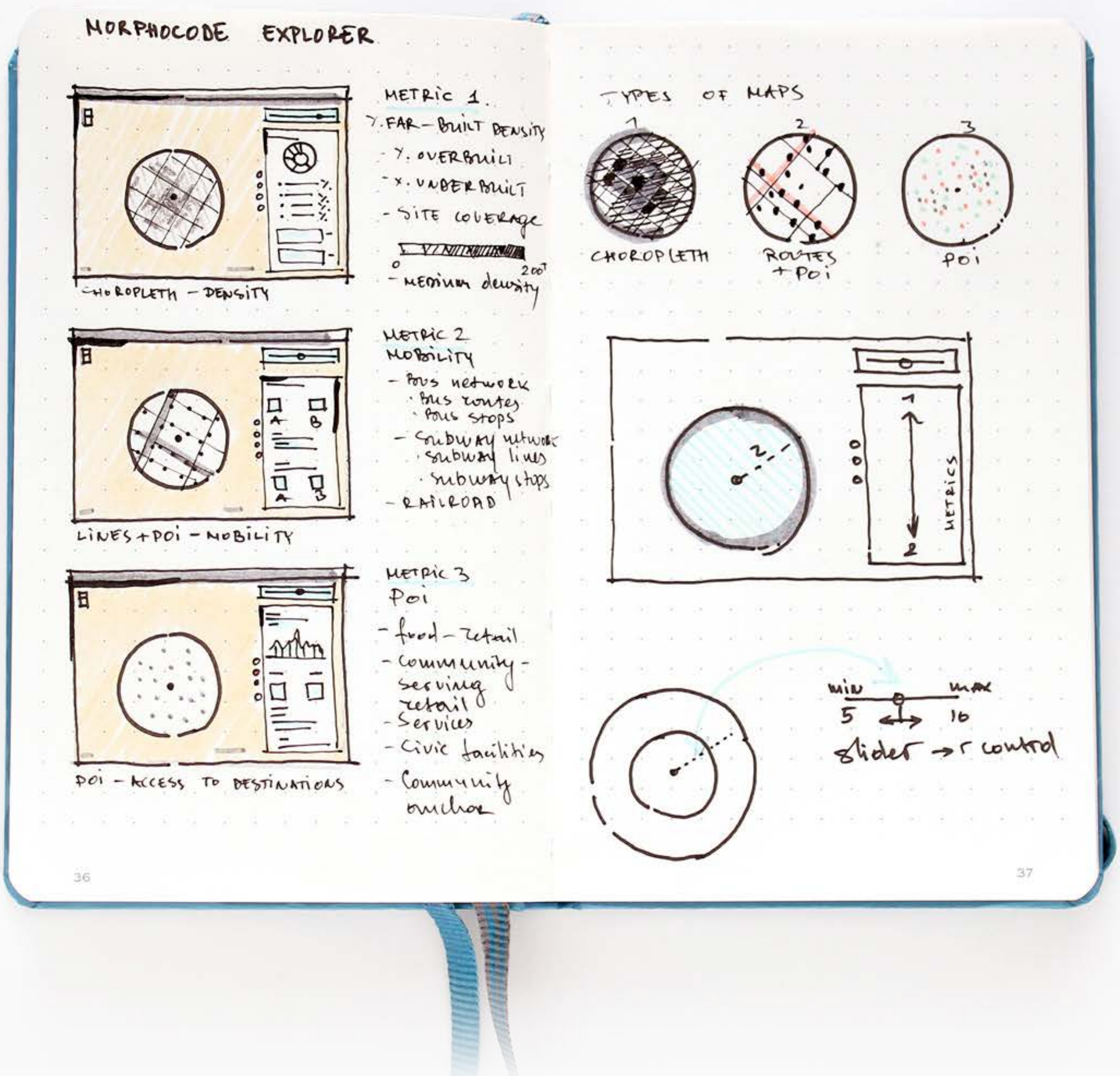
Building an interactive tool for data exploration consists of three main tasks: designing the user experience, transforming the various raw datasets into a compressed data format, and developing the "live" functionality using modern web technologies and APIs.

Since the early UX sketches, the design goal was to keep the interface minimal while still providing a data-rich experience.

UX Design

Data Pipeline

Web Development



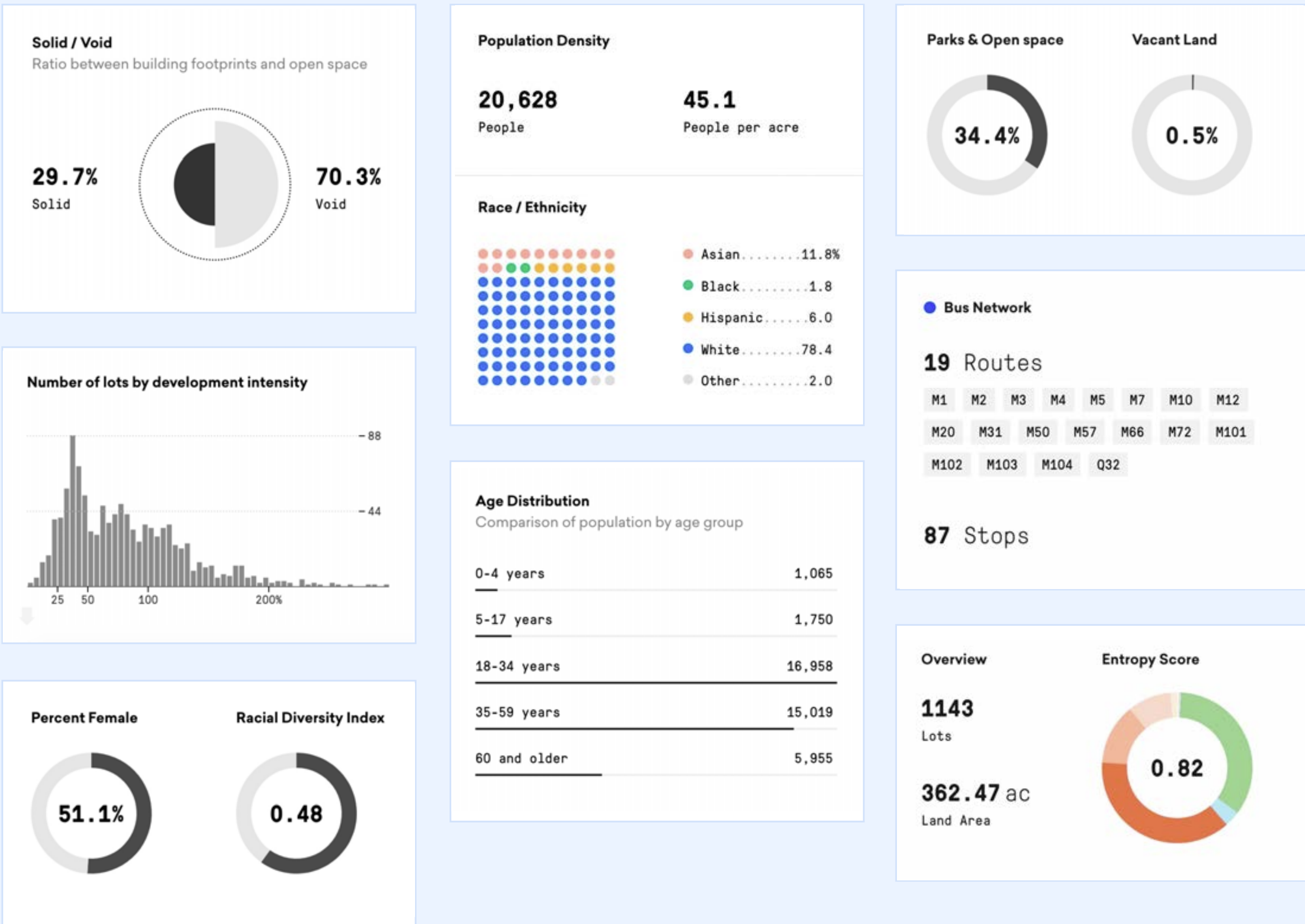
Data visualization

Presenting large amounts of data in a single view is a challenging task. There is a risk of bloating the interface with too many options and ultimately overwhelming the user with various checkboxes, toggles, and drop-downs.

Good design introduces a clear visual hierarchy that guides the eye and brings attention to the most important elements of the interface.

It is essential to use a consistent visual language and choose visualization techniques based on the nature of your data.

We experimented with different data visualization typologies and ended up developing various components, including proportional area charts, histograms, donut charts, bar charts, and dot matrixes.



Data Layers

At the core of Morphocode Explorer are various datasets: *census data, tax lot information, transit routes, building footprints*, *etc*. These datasets are acquired from multiple sources and come in a variety of file formats.

For example, the *Transit Network* layer is composed of over 15 different datasets — the subway lines are extracted from a static *GTFS feed* provided by *MTA*, the New Jersey railroads are published as a shapefile, the *Staten Island* railroad is extracted from the *LION* dataset, while the *Amtrak* routes are retrieved from *OpenStreetMap*.

We use python to clean, transform, merge, and refine the datasets. This approach helps document and automate data processing.

Building a custom data pipeline

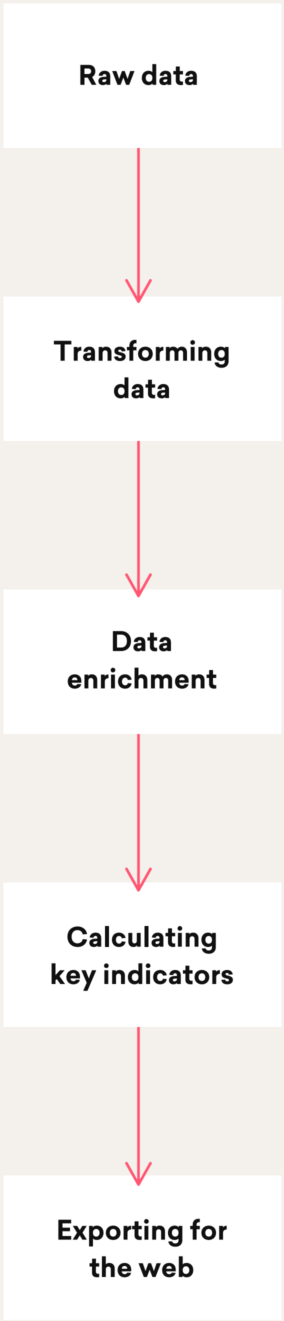
01 It all starts with acquiring the raw datasets: these could be geospatial datasets of building footprints and tax lots, GTFS feeds specifying transit schedules or third-party datasets in a proprietary format.

02 Data can be messy: it comes from various sources, and often doesn't have structure, or contains errors and missing fields. You need to clean, filter, and refine the datasets before making use of them.

03 You can enrich the original dataset by merging multiple data sources. This process lets you combine geographic and attribute data to gather more information about the study area.

04 By calculating key urban indicators, you can answer questions such as how to improve access to transit, is there a good mix of land uses, or how diverse is a neighborhood.

05 To perform analysis in the browser, you need to export the geospatial data into a set of map tiles. These tiles contain vector data that can be indexed and queried efficiently by Morphocode Explorer.



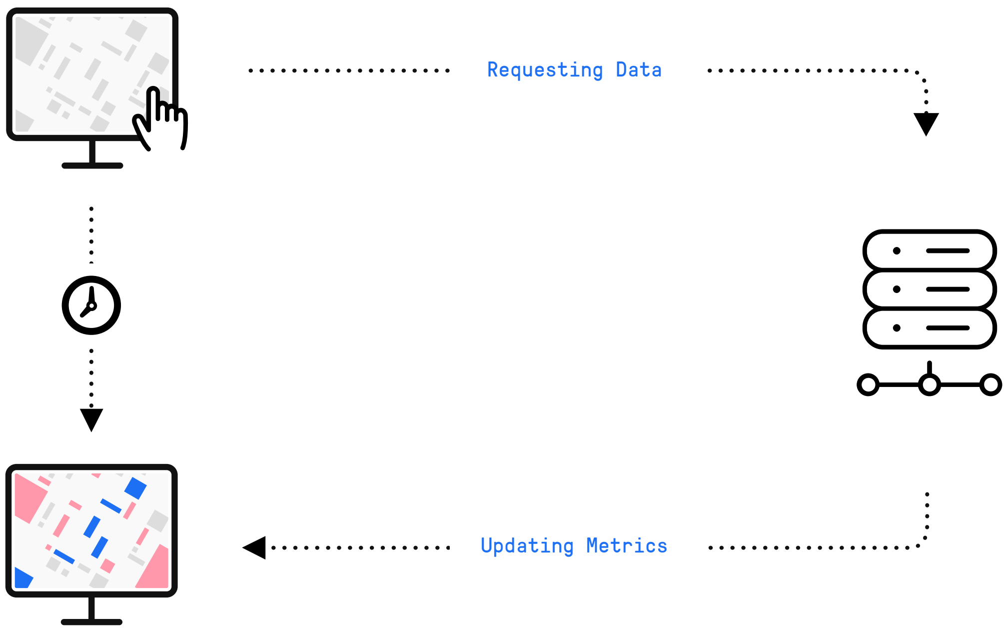
The Challenge

Traditionally, location analysis is done on the desktop using GIS and statistical applications such as *ArcGIS*, *QGIS*, and *RStudio*. These applications are more powerful than the browser when it comes to crunching large amounts of data and performing spatial analysis.

Analyzing large datasets in the browser is possible, but there's a “catch” — the heavy computations must be offloaded to a remote database that is powerful enough to make the analysis. For example, the web platforms *OmniSci* and *Kinetica* run on top of powerful GPU-based engines, *Carto* uses *PostgreSQL* under the hood, while the *ArcGIS API* lets you query an *ArcGIS* server.

This client-server architecture lets you scale your analysis to billions of data points. The downside is that your browser has to keep making requests to the server. This causes a noticeable delay between dragging the pedshed and updating the metrics.

To achieve real-time interaction, the data analysis must happen in the browser. This approach removes the delay associated with client-server communication.

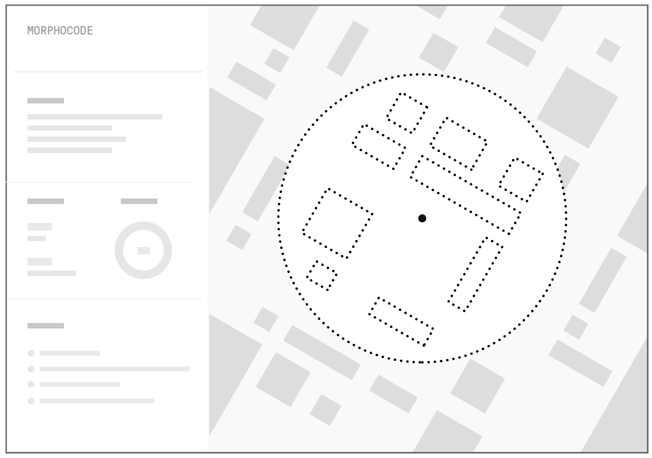


Real-time interaction
The algorithm

01

Find all features within the study area

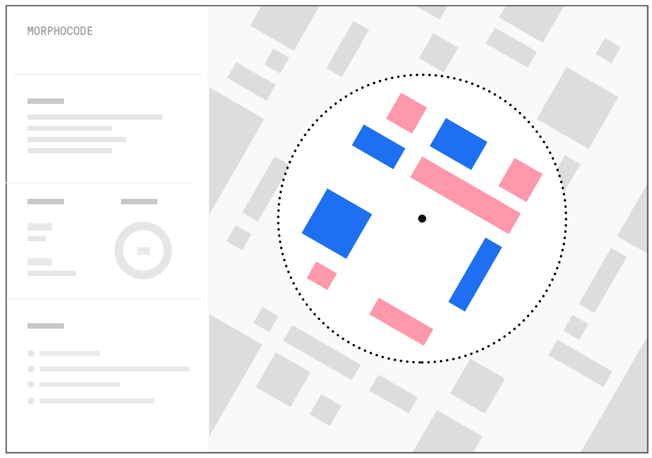
This is a geospatial operation known as a *spatial query*. To speed up the query, Morphocode Explorer checks whether the geometric center of each feature is within the circular buffer.



02

Draw only the selected features

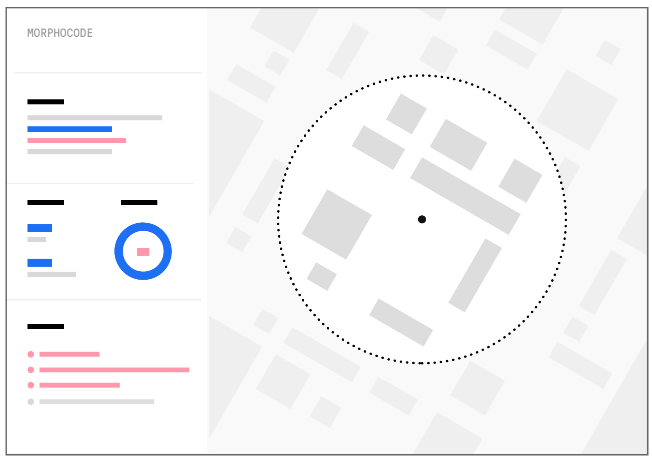
Morphocode Explorer uses the open-source library mapbox-gl-js to render the map. The library is extremely fast because it draws the features using WebGL. Nevertheless, we ended up customizing how mapbox-gl-js works under the hood to speed up the rendering algorithm.



03

Calculate the metrics and update the charts

The metrics are calculated on the fly as you drag the pedshed. The charts in the sidebar are optimized for fast updates using d3.js



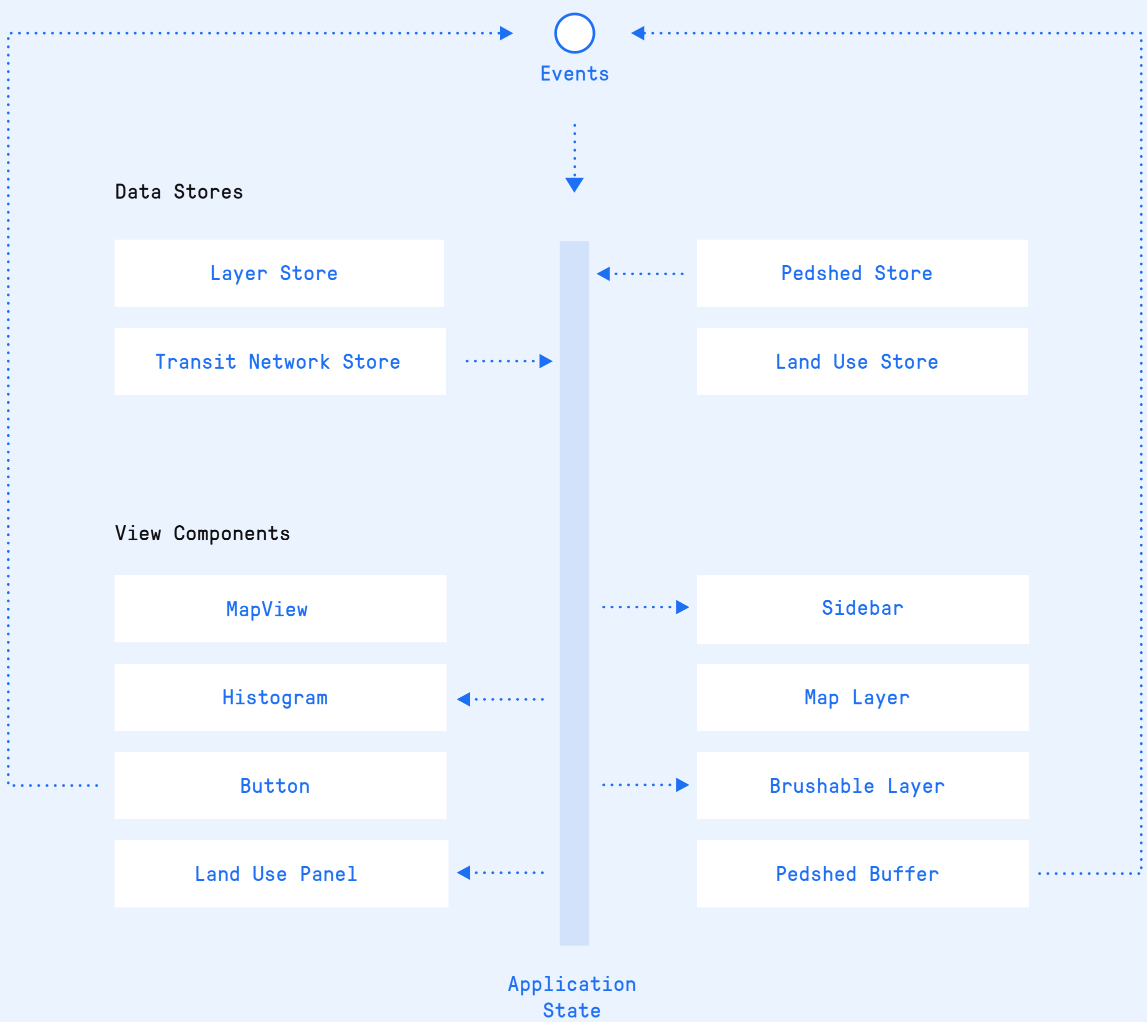
Application architecture

The front-end of Morphocode Explorer is written using modern JavaScript. It takes advantage of ES6 modules, arrow functions, destructuring, async/await, and other newer features of the language. The source code is bundled and compiled to ES5 using rollup and bublé.

Due to the interactive nature of the application, there are a lot of moving parts. For example, dragging the pedshed redraws the map, but it also triggers an update of the metrics; scrolling through the sidebar updates the map layers, but it also fires network requests to fetch new data.

Keeping track of these dependencies can quickly get out of control and lead to bugs. To solve this, Morphocode Explorer uses a *Flux*-style application architecture popularized by Facebook. The source code is organized into *data stores, view components*, and a central *action dispatcher.*

Data flows in one direction — from the data stores to the view components. Changes in the application state occur in response to events dispatched through the action dispatcher.



Discover more

Starting a project? Morphocode Explorer can be customized to meet specific requirements. Get in touch if you want to learn more about the tool and how you can integrate it into your existing workflow.

We'd love to talk to you about what Morphocode Explorer does and how we might help.

Get in touch

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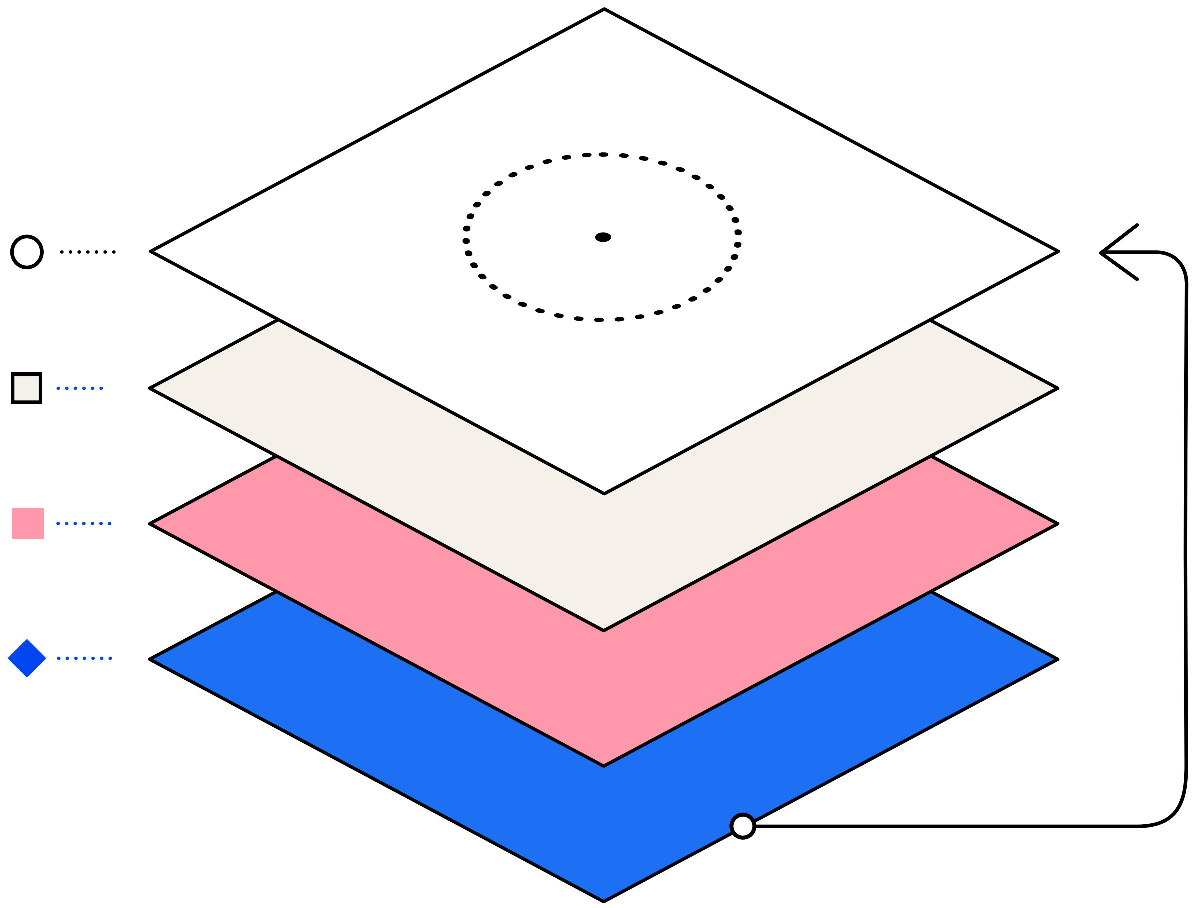
Learn with Morphocode

Morphocode Academy is an online school that covers topics in data visualization, creative coding, and urban informatics. You can visit the academy page to learn more about the use of color in maps, what are the most popular tools for data exploration, and how to use python to do data analysis.

You can also check out our video course Mapping Urban Data. It contains 30 carefully organized and beautifully illustrated videos that will lay a solid foundation for your mapping skills.

www.morphocode.com/academy



Exploring cities through data analysis and visualization

MORPHOCODE

Morphocode is a design and development firm that uses data to visualize urban dynamics. Our team brings together expertise across architecture, urban planning, and software engineering. We build data-driven dashboards, create beautiful interactive experiences, and make custom tools for data analysis and visualization.

To learn more, visit www.morphocode.com or follow us on Twitter @morphocode

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